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Effect of nitrogen fertilization on growth, nodulation and biomass yield of green manure crops

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Abstract: The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from 8 April 2004 to 23 June 2004 to investigate the effect of nitrogen rate on plant height, biomass yield and nodulation of green manure crops. The experiment consisted of seven green manure crops viz. *Sesbania rostrata, Sesbania aculeata, Crotalaria juncea, Vigna unguiculata, Phaseolus mungo, Vigna radiata* and *Glycine max* and three nitrogen levels viz. 10,15 and 20 kg N ha^{-1} The experiment was laid out in a randomized complete block design with three replications. A significant variation was observed among the green manure crops in terms of plant height. *S. rostrata* appeared as the tallest and *V. unguiculata* as the shortest green manure crop. *C. juncea* showed rapid growth at the early stage up to 45 days after sowing (DAS) but *S. rostrata* showed the opposite growth behaviour as was observed in *C. juncea* . Plant height and fresh biomass increased progressively with higher levels of nitrogen but number of nodules plant^{-1} decreased with higher levels of nitrogen and vice- versa. Number of nodules plant^{-1} increased with the age of the plants up to 60 DAS and declined thereafter at 75 DAS. It may be concluded that *S. rostrata, S. aculeata, C. juncea,*and *P. mungo* appeared as the promising green manure crops in terms of biomass yield.
Key words: Green manure crops, nitrogen, nodulation, biomass.

Introduction

Legumes are considered to be important components of subsistence cropping systems of the semi-arid tropics because of their ability to convert atmospheric nitrogen (N_2) into the assimilable form of ammonia, to add substantial amounts of organic matter to the soil, and to grow better than many other crops with low inputs under harsh climatic and edaphic conditions. The global concern about sustainable agricultural systems further highlights the significance of legumes as green manure, which offer a renewable source of energy through biological nitrogen fixation (BNF). Annual global BNF has been estimated at around 175 million tons of N of which about 79% is accounted by terrestrial fixation (Burns and Hardy, 1975). This clearly shows that legumes are an economically attractive and ecologically sound means of reducing external fertilizer N input and improving the quality and quantity of internal resources. Depending upon physical, environmental and biological factors, legumes can fix N_2 up to 450 kg ha^{-1}(e.g., soybean). A considerable part of N_2 fixed by legumes is, however, harvested and removed as grains. The N left in the legume residue generally benefits succeeding crops (Mayers and Wood, 1987).

Nitrogen is the most critical plant nutrient for growth and yield of cultivated crops. However, legumes drive a large portion of their N requirement through BNF and consequently only a starter dose of 20-25 kg N ha^{-1} is usually recommended. In fertilizer experiment in farmers fields under the All India Coordinated Agronomy Research Project (AICARP), chickpea showed substantial response to 20 kg N ha^{-1}. However, in rice fields where the rhizobial population is often low, late-sown chickpea responds well up to 40 kg N ha^{-1}(Ali, 1994). Pea, generally grown under irrigated conditions, has also shown good response to high doses of N. Small application of phosphorous (P) 13-26 kg ha^{-1} and N 15-25 kg ha^{-1} fertilizers may increase GML biomass up to 1.2 t ha^{-1} and N accumulation up to 30 kg N ha^{-1}, particularly in soils of low fertility (Yadvinder–Singh *et al*., 1991) and observed that N content in legume green manures (LGMs) was also affected by the age of the green manure, with optimal levels at 45 days and declining percentages in 60-day old green manure.

Despite constraints in green manure cultivation, it is anticipated that use of green manure will expand in the near future because of the rising demand for and costs of inorganic fertilizers (Meelu *et al.,* 1992). More importantly green manure is being advocated as a sustainable agricultural practice to regenerate depleted soil resources and boost declining yields. This approach is specially pertinent in South and Southeast Asia, where recent observations of stagnant or declining yields, under intensive, continuous rice cropping and in the rice- wheat rotation, have raised concerns about long-term sustainability and possible adverse environmental impacts of these systems (Flinn and De Datta, 1984; Giri *et al.*, 1993). Detail information about growth pattern, nodulation behaviour as well as their biomass yield of green manure crop is needed. A few research was preformed earlier where some partial information is available. The present study was, therefore, undertaken to observe the performance green manures as affected by nitrogen fertilization.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from 8 April 2004 to 23 June 2004 to investigate the effect of nitrogen rate on plant height, biomass yield and nodulation of green manure crops. The experiment consisted of seven green manure crops viz. *Sesbania rostrata, Sesbania aculeata, Crotalaria juncea, Vigna unguiculata, Phaseolus mungo, Vigna radiata* and *Glycine max* and three nitrogen levels viz. 10 kg (100% of the recommended dose), 15 kg (150% of the recommended dose) and 20 kg N ha^{-1} (200% of the recommended dose). The recommended nitrogen dose was taken as per Singh *et al.* (1981). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.0m × 2.5m.

The land was prepared by a power-tiller with several ploughings and cross ploughings followed by laddering to level the land. Weeds and other plant residues were collected and removed from the field. The land was fertilized with P, K and S at 18, 26 and 12 kg ha^{-1}, respectively at final land preparation in the form of triple super phosphate, muriate of potash and gypsum. Different doses of N were applied in the form of urea according to treatment specification at final land preparation. Seeds of green manure crops were sown on 8 April 2004 in all unit plots randomly as per layout of the experiment. Five plants were randomly selected in each plot for each destructive sampling to record the data on plant height, fresh biomass and number of nodules plant^{-1} at 15 day intervals beginning from 30 days after sowing (DAS) up to 75 DAS. Collected fresh samples were oven dried in an electrical oven at 65^{0}C for 72 hours to record the dry biomass yield. Central five square metres area in each plot was harvested to record the fresh biomass yield plot^{-1}, which was converted to t ha^{-1}. The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of the computer package M-STAT. Means were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height: A significant variation in plant height was observed among the green manure crops at different days after transplanting (DAS). At 30 and 45 DAS, *C. juncea* was observed as the tallest plant (Table 1). *S. aculeata* and *S. rostrata* occupied the second and the third highest position, respectively. *V. radiata*, *P. mungo* and *V. unguiculata* exhibited statistically similar results and *G. max* occupied the last position in this regard. At 60 DAS, *S. rostrata* superseded all occupying the first position followed in order by *S. aculeata, C. juncea, P. mungo,* and *V. radiata*. *G. max* and *V. unguiculata* occupied the last position in this regard. At 75 DAS all the green manure crops showed similar performance in terms of plant height as was observed at 60 DAS. It was observed that *S. rostrata* exhibited slower plant growth at early stage up to 45 DAS but on plant height increased rapidly and superseded all at 60 DAS. *S. aculeata* exhibited similar trend of plant height during the growth period. On the other hand, *C. juncea* showed reverse trend of plant growth as was observed in *S. rostrata*. While other green manure crops showed linear sequence of plant height during the growth period. Variation of plant height might be due to individual genetic characteristics of different green manure crops.

Table 1. Plant height of green manure crops at different days after sowing (DAS)

Green manure crops	Plant height (cm)			
	30DAS	45DAS	60DAS	75DAS
Sesbania rostrata	38.22c	97.53b	154.73a	171.4a
Sesbania aculeata	40.93b	99.53ab	147.98b	164.96b
Crotalaria juncea	45.20a	101.80a	142.36c	155.69c
Vigna unguiculata	26.31d	38.53d	55.31f	63.67e
Vigna radiata	27.13d	37.86d	61.47de	72.33d
Phaseolus mungo	25.44d	41.20c	63.53d	75.51d
Glycine max	21.53e	36.64d	58.69ef	65.27e
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letter do not differ significantly whereas figures having dissimilar letter(s) differ significantly (as per DMRT)

Plant height was significantly influenced by nitrogen fertilization up to 75 DAS (Table 2). The highest plant heights at 30, 45, 60 and 75 DAS, respectively were observed when all the crops were fertilized with 20 kg N ha^{-1}. The result followed by the application of 15 kg N ha^{-1}. The lowest plant heights at 30, 45, 60 and 75 DAS, respectively were observed with the application of 10 kg N ha^{-1}. It was observed that plant height increased progressively with the higher doses of nitrogen irrespective of green manure crops. Thus N emerged out as a growth promoting plant nutrient for green manure crops.

Table 2. Plant height of green manure crops as affected by nitrogen fertilization at different DAS

Nitrogen rate (kg ha-1)	Plant height (cm)			
	30DAS	45DAS	60DAS	75DAS
10	29.72c	62.17c	95.06c	106.86c
15	32.02b	64.58b	97.63b	109.76b
20	34.56a	67.44a	100.47a	112.88a
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letter do not differ significantly whereas figures having dissimilar letter(s) differ significantly (as per DMRT).

Plant height was not significantly influenced by the interaction of green manure crops and nitrogen fertilization. But a numerical increasing trend of plant height was observed with higher doses of nitrogen in every combination treatment.

Nodule number plant^{-1}

Significant variation in nodule production plant-1 was observed among the green manure crops at different DAS (Table 3). At 30 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *P. mungo* and *S.*

rostrata produced similar number of nodules plant^{-1} occupying the second position followed by *C. juncea*, *V. radiata*, *G. max* and *V. unguiculata*. At 45 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata* followed in order by *S. rostrata*, *P. mungo*, *C. juncea*, *V. radiata*, *G. max* and *V. unguiculata*. At 60 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. The second highest and similar number of nodules plant^{-1} was observed in *S. rostrata* and *P. mungo* followed in order by *C. juncea* *V. radiata*, *G. max* and *V. unguiculata*. At 75 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *S. rostrata* and *C. juncea* produced similar number of nodules plant^{-1} occupying the second position followed in order by P. *mungo*, *V. radiata*, *G. max* and *V. unguiculata*. It was observed that number of nodules plant^{-1} increased progressively up to 60 DAS and then declined irrespective of green manure crops which might have occurred due to aging of plants and adverse environmental condition (continuous rainfall) prevailed at that period.

Table 3. Number of nodules plant^{-1} of green manure crops at different days after sowing

Green manure crops	Number of nodules (plant^{-1})			
	30DAS	45DAS	60DAS	75DAS
Sesbania rostrata	16.93b	26.44b	28.56b	21.93b
Sesbania aculeata	20.80a	31.64a	36.80a	32.82a
Crotalaria juncea	15.49c	22.51d	26.04c	20.57b
Vigna unguiculata	10.20e	10.91g	13.56f	8.6f
Vigna radiata	13.58d	20.53e	23.62d	14.24d
Phaseolus mungo	17.04b	24.76c	27.71b	16.80c
Glycine max	12.64d	16.62f	17.93e	11.29e
Level of significance	0.01	0.01	0.01	0.01

Table 4. Number of nodules plant^{-1} of green manure crops as affected by nitrogen fertilization at DAS

Nitrogen rate (kg ha^{-1})	Number of nodules plant^{-1}			
	30DAS	45DAS	60DAS	75DAS
10	16.00a	22.77a	25.97a	18.36
15	14.97b	21.73b	24.98a	18.26
20	14.75b	21.07c	23.71b	17.84
Level of significance	0.01	0.01	0.01	NS

In a column, figures having similar letter(s) or without letter do not differ significantly whereas figures having dissimilar letter(s) differ significantly (as per DMRT), NS = Not significantly different at $p \leq 0.05$

Nodules plant^{-1} was significantly influenced by nitrogen fertilization up to 60 DAS (Table 4). The highest number of nodules plant^{-1} was produced when the crops were fertilized with 10 kg N ha^{-1} followed by 15 kg N ha^{-1} and the lowest number of nodules plant^{-1}was produced at 20 kg N ha^{-1}. It was observed that number of nodules plant^{-1} was depressed with higher doses of nitrogen might be due to vigorous vegetative growth. Number of nodules plant^{-1} was not significantly influenced by the interaction of green manure crops and nitrogen fertilization.

Fresh biomass yield: Fresh biomass yield was significantly influenced by different green manure crops (Table 5). At 30 and 45 DAS, the highest fresh biomass yield was observed in *C. juncea* followed in order by *S. aculeata, S. rostrata, P. mungo, V. radiata, V. unguiculata* and *G. max*. At 60 DAS, the highest fresh biomass yield was observed in *S. rostrata*. *S. aculeata* and *C. juncea* produced similar fresh biomass occupying the second posotion followed by *P. mungo, V. radiata, V. unguiculata* and *G. max*. At 75 DAS, the highest fresh biomass yield was observed in *S. rostrata* and almost similar result was observed in *S. aculeata* followed in order by *C. juncea, P. mungo, V. radiata, V. unguiculata* and *G. max*. It was observed that *S. rostrata* produced less biomass at earlier stage of plant growth up to 45 DAS and superseded all at 60 and 75 DAS. While *C. juncea* exhibited reverse trend as was observed in *S. rostrata. S. aculeata* showed linear trend of fresh biomass yield during the growth period up to 75 DAS. It was further observed that *S. rostrata, S. aculeata* and *C. juncea* showed progressively increasing trend of fresh biomass production with the age of the plants up to 75 DAS. On the other hand, *P. mungo, V. radiata*, *V. unguiculata* and *G. max* showed progressively increasing trend of fresh biomass yield up to 60 DAS and then depressed at 75 DAS which might be due to aging and leaf abscission. Variation of fresh biomass yield might be due to individual genetic characteristics of green manure crops.

Fresh biomass yield was significantly influenced by nitrogen fertilization at all days after sowing (Table 6). The highest fresh biomass yield at 30, 45, 60 and 75 DAS were observed by the application of 20 kg N ha^{-1}, the highest doses for cultivation of green manure crops. The result followed in order by 15 kg and the lowest fresh biomass yield was obtained when the crop was fertilized with 10 kg N ha^{-1}. The table showed that fresh biomass yield increased progressively with higher doses of N which indicated positive response of green manure crops on N. Similar results were reported by Saxena and Sheldrake (1980), who reported that chickpea showed substantial response to 20 kg N ha^{-1} and when N_2 fixation system was operative chickpea did not respond to N beyond 20 kg ha^{-1}. Fresh biomass yield was not influenced significantly by the interaction of green manure crops and nitrogen fertilization. But numerically an increasing trend of fresh biomass yield was observed with higher doses of nitrogen in all treatment combinations.

Table 5. Fresh biomass yield of green manure crops at different days after sowing (DAS)

Green manure crops	Fresh biomass yield (t ha^{-1})			
	30DAS	45DAS	60DAS	75DAS
Sesbania rostrsta	2.73c	8.8b	18.87a	26.62a
Sesbania aculeata	3.03b	8.49ab	16.98b	25.38ab
Crotalaria juncea	3.54a	8.90a	15.98b	23.84b
Vigna unguiculata	2.14e	5.13d	8.26d	7.86de
Vigna radiata	2.23de	5.49cd	8.80cd	8.71cd
Phaseolus mungo	2.41d	5.74c	9.91c	9.58c
Glycine max	1.86f	4.82e	6.78e	6.57e
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letters do not differ significantly where as figures bearing dissimilar letter(s) differ significantly (as per DMRT)

Table 6. Fresh biomass yield of green manure crops as affected by nitrogen fertilization at DAS

Nitrogen rate (kg ha^{-1})	Fresh biomass yield (t ha^{-1})			
	30DAS	45DAS	60DAS	75DAS
10	2.40c	6.10c	11.83b	15.06b
15	2.55b	6.74b	12.23ab	15.51ab
20	2.74a	7.16a	12.61a	15.95a
Level of significance	0.01	0.01	0.01	0.05

In a column, figures having similar letter(s) or without letters do not differ significantly where as figures bearing dissimilar letter(s) differ significantly (as per DMRT)

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